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COVER PHOTO: Figure 1. A typical pasture scene in Hawaii.

Supplemental Vitamin A For Beef Cattle

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Many of the early concepts concerning the requirements and status of vitamin A in beef cattle underwent re-evaluation in the late 1950's after deficiency symptoms were observed in steers fed standard fattening rations. Since that time, considerable attention has been focused upon the apparent increase in the requirements and factors which may influence the vitamin A status of beef cattle. The vitamin A status of an animal refers to the total reserve supply of vitamin A available in the body including liver stores and blood plasma levels. This status is transitory and is affected primarily by level of vitamin A intake and various production and environmental stresses.

Vitamin A is an essential vitamin for ruminants and must be supplied in adequate quantities to insure optimum performance. Beef cattle derive vitamin A from two sources: pro-vitamin A (beta-carotene) and supplemental vitamin A. Pro-vitamin A is widely distributed in forages—particularly green grass, forage crops, and silages—and green, leafy hays. Mature or weathered forages usually have low vitamin A potency as do most grains and protein supplements. Pro-vitamin A must be converted to vitamin A to function in the animal's body. The primary sites of this conversion are the villi of the intestinal wall. The essential functions of vitamin A are maintenance of the epithelial tissues (skin and lining of the digestive, respiratory, and reproductive tracts); synthesis of visual purple, a compound required for normal eyesight; and normal bone, teeth, and nerve development.

Research results from many experiment stations indicate that the vitamin A status of beef cattle can be altered by factors such as disease and parasites, increased rate of performance, nutrient interrelationships, nutrient deficiencies, poor conversion of carotenes to vitamin A, and high environmental temperatures. Response to supplemental vitamin A is usually higher under feedlot conditions; however, various reports indicate that supplemental vitamin A may improve performance on pasture and when feeding silage or hay.

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Few data are available regarding supplemental vitamin A for grazing beef cattle in Hawaii. These studies were conducted (1) to evaluate the effects of supplemental vitamin A, and (2) to compare injectable and oral vitamin A sources upon the performance of beef cattle under various grazing conditions in Hawaii.

LITERATURE REVIEW

Varying results have been reported from experiments designed to study the effects of supplemental vitamin A for beef cattle. Several investigators have reported that supplemental vitamin A improved steer gains in the feedlot *(4, 19, 23)* and on pasture or when feeding hay or silage *(8, 19)*. Others have found no benefit from additional vitamin A for steers under either of these conditions *(7, 8, 9, 13, 17, 20, 24, 30, 32, 34)*. Several studies with range beef cows have shown that vitamin A supplementation had little or no effect on reproductive performance and calf production *(21, 22, 31)*. Long-term depletion studies *(22)* indicate that beef cows can subsist up to 43 months before deficiency symptoms occur. These deprivations did not affect conception, but abortions occurred during the sixth and seventh month of the third pregnancy. Calves born to deficient cows exhibited the classical symptoms of vitamin A deficiency by about 8 weeks of age, but improved within a few days when treated *(22)*.

Vitamin A deficiencies under practical conditions are usually not caused by the implication of a single factor. Recent reports indicate that interrelationships between other nutrients and compounds in the ration can affect the utilization of vitamin A. Reports from the Iowa Station *(15, 16)* indicate that vitamins E and K improved the utilization of vitamin A. Phosphorus deficiency has been shown to reduce the utilization of vitamin A by beef cattle *(12, 22, 28)*. Similarly, protein deficiency or natural protein inadequacy through the use of high levels of nonprotein nitrogen sources may also reduce the efficiency of vitamin A utilization *(1, 6, 10, 26)*.

Forages which contain high levels of nitrates have been associated with reduced vitamin A status, particularly liver stores, in beef cattle. Earlier research *(11, 25, 35)* indicated that nitrates destroyed vitamin A in the rumen; however, more recent studies *(13, 29, 33, 34)* reveal that nitrates were not directly involved in vitamin A destruction. Further studies indicate that nitrates inhibit thyroid function and that the thyroid is concerned with the conversion of carotene to vitamin A *(5, 29)*. Other factors which affect thyroid function such as heat stress from high environmental temperatures may subsequently reduce the vitamin A status and increase requirements *(14, 29)*.

The rate and efficiency of conversion of plant carotenes to vitamin A is an important factor in meeting the vitamin A requirements for cattle. Vitamin A depletion studies have indicated that steers could efficiently utilize forage carotenes to meet the vitamin A requirements *(17)* while others have shown that liver vitamin A stores were depleted under similar experimental conditions *(14, 27)*.

Studies designed to determine optimum levels of supplemental vitamin A indicate that daily feeding of up to 3,000 International Units (I.U.) per 100 lb. body weight improved gains. Higher levels provided little additional benefit for growing and fattening beef steers (*3, 4, 19*). Similar studies with beef cows have shown responses to vitamin A levels up to 4,000 I.U. per 100 lb. body weight per day during gestation and lactation. These responses were largely dependent upon previous vitamin A intake and existing liver reserves (*22*). Most authors agree that responses to vitamin A are dependent upon the vitamin A status of the animal which is largely determined by previous vitamin A intake and degree of depletion of liver stores. Intramuscular or intraruminal injections of 1 to 3 million I.U. can also be used to provide supplemental vitamin A. Both of these vitamin A sources appear to be utilized equally well by beef cattle. There have been no reports of toxicity or undesirable side effects from vitamin A supplementation.

PROCEDURE

This experiment included five trials conducted at four ranches located on the island of Hawaii and involved a total of 311 yearling steers and 23 heifers. The animals were randomly allotted into equal treatment groups in all trials. Injectable vitamin A was studied at three levels, 0, 500,000, and 1,000,000 I.U. injected intramuscularly at the initiation of the trial, and oral vitamin A fed at two levels, 0 and 20,000 I.U. per head daily. The level of vitamin A supplementation remained constant in each trial. Four trials involved only injectable vitamin A and the heifers were all included in one of these trials. In another of these trials, 75% of the animals in both the control and the vitamin A-injected groups received equal levels of supplemental feed. Animals in all trials had free access to complete mineral mixtures containing an average of 17% calcium and 9% phosphorus.

In the fifth trial, main treatment groups were control and 20,000 I.U. oral vitamin A palmitate per head daily. One-half of the animals in each main treatment group were injected with 1,000,000 I.U. vitamin A at the initiation of the trial. The vitamin A palmitate was added to the mineral mixture in concentrations to furnish 20,000 I.U. vitamin A per 0.2 lb. mineral mix. This concentration was based on 0.2 lb. mineral consumption per head daily which had been established in previous mineral supplementation trials.

In each trial, the animals were individually identified by ear-tag and/or ear-tattoo and individually weighed at the initiation and at periodic intervals during the trial. Initial and final weighings were preceded by overnight shrink periods.

The forage type, quality, and quantity varied considerably between trials. The major forage species utilized were guinea grass (*Panicum maximum*), kikuyu grass (*Pennisetum clandestinum*), pangola grass (*Digitaria decumbens*), and a combination pasture composed primarily of pangola grass and trefoil (*Lotus* sp.) with some kikuyu grass and Dallis grass (*Paspa-*

FIGURE 2. Steers grazing kikuyu grass (*Pennisetum clandestinum*) in Hawaii.

FIGURE 3. Steers grazing pangola grass (*Digitaria decumbens*) in Hawaii.

FIGURE 4. A kikuyu grass (*Pennisetum clandestinum*) pasture in Hawaii.

lum dilatatum). (See figures 2, 3, and 4.) Stocking rates were consistent with the management practices of the particular ranch. Representative forage samples were taken from the pastures during each trial. (See figure 5.) Proximate and carotene analyses were conducted by A.O.A.C. (2) methods.

RESULTS AND DISCUSSION

The results of three separate trials with yearling steers injected with 500,000 I.U. vitamin A while on pasture are presented in table 1.

There were no significant ($P>0.05$) differences between the average daily gain for the control and supplemental vitamin A groups in any of the three above trials. Average daily gains were essentially the same for the two groups in trial 1 (1.01 lb. vs. 1.02 lb.). The gains were slightly lower for the vitamin A group when compared to the control group in trial 2. In trial 3, 75% of the steers in both the control and vitamin A groups received equal levels of supplemental feeds during the trial. Ten steers in each group were fed 1.5 lb. of a 32% protein supplement per head daily for the entire trial, ten others were fed 3.0 lb. of a 15% crude protein and 75% T.D.N. ration per head daily for the entire trial, and ten others were fed 15 lb. of the 15% crude protein, 75% T.D.N. ration per head daily for the

TABLE 1. Performance of grazing yearling steers injected with 500,000 I.U. Vitamin A

TREATMENT	CONTROL	VITAMIN A
Trial 1		
Number of steers	30	29
Average weights (lb.)		
Initial (8–19–64)	376.5	373.4
Final (11–5–64)	455.6	452.8
Total gain (78 days)	79.1	79.4
Average daily gain (78 days)	1.01	1.02
Trial 2		
Number of steers	26	19
Average weights (lb.)		
Initial (8–19–64)	377.1	375.8
Final (11–5–64)	454.2	445.0
Total gain (78 days)	77.1	69.2
Average daily gain (78 days)	0.99	0.89
Trial 3		
Number of steers	40	40
Average weights (lb.)		
Initial (1–15–64)	451.0	449.0
Final (7–9–64)	709.0	700.0
Total gain (182 days)	258.0	251.0
Average daily gain (182 days)	1.42	1.38

last 25 days of the trial. The remaining ten steers in each group received no supplemental concentrate. There were no significant benefits from supplemental vitamin A in trial 3.

Trial 4 was conducted with both steers and heifers randomly allotted to treatment within sex. The animals in the treated group were injected with 1,000,000 I.U. vitamin A at the initiation of the trial. This trial was conducted under dry conditions with no rainfall for approximately 2 months prior to or during the trial. The results of trial 4 are given in table 2.

TABLE 2. Performance of grazing yearling steers and heifers injected with 1,000,000 I.U. vitamin A (trial 4)

TREATMENT	CONTROL	VITAMIN A
Number of animals	29	20
Average weights (lb.)		
Initial (8–20–64)	454.6	440.0
Final (11–4–64)	462.8	442.2
Total gain (76 days)	8.2	2.2
Average daily gain (76 days)	0.11	0.03

FIGURE 5. Sampling forage from a combination species pasture in one of the vitamin A trials.

Average daily gains were 0.11 lb. and 0.03 lb. for the control and vitamin A groups, respectively. As was observed in trials 2 and 3, the group receiving the supplemental vitamin A had lower gains than the controls, however the reduction was not significant ($P>0.05$). The responses for heifers compared to steers were similar in both groups, indicating that treatment effects were not influenced by sex.

The results of the trial to evaluate oral vitamin A and to compare oral and injectable vitamin A are reported in table 3. These data are the combined results of two replications conducted during the period January to June in 1964 and 1965.

TABLE 3. Effect of oral and injectable vitamin A upon the performance of grazing yearling steers (trial 5)

Oral vitamin A, I.U./head daily	0		20,000	
Injectable vitamin A, I.U., millions	0	1	0	1
Number of steers	29	28	23	21
Average weights (lb.)				
Initial (average 1964–65)	515.4	509.2	513.7	504.3
Final (average 1964–65)	723.9	733.6	727.4	722.1
Total gain (142 days)	208.5	224.4	213.7	217.8
Average daily gain (142 days)	1.47	1.58	1.50	1.53

Average daily gain was slightly higher for all groups receiving vitamin A compared to the controls. Steers receiving the injectable vitamin A gained somewhat faster than those receiving oral vitamin A (1.58 lb. vs. 1.50 lb.), but there was no additional advantage when both sources were given simultaneously (1.53 lb. average daily gain). The average daily gain was 1.54 lb. when all vitamin A-treated groups were combined, which represented a 4.8% increase over the 1.47 lb. for the control group. The differences in average daily gain observed in trial 5 were not statistically significant ($P>0.05$). The vitamin A palmitate was fed in the mineral mix in this trial and concentrations were based upon an average daily consumption of 0.2 lb. The average daily mineral consumption was 0.19 lb., indicating that actual consumption of vitamin A palmitate was in very close agreement with the previously determined intake.

Forage samples were taken from the pastures during each trial. Chemical analyses of these samples are presented in table 4.

TABLE 4. Average composition of forages in all trials

TRIAL NUMBER Major forage grass (es)	1 Guinea	2 Pangola Kikuyu	3 Pangola	4 Kikuyu	5 Pangola
Dry matter, %	19.6	21.2	29.9	64.0	23.1
Proximate composition, dry matter basis, %					
Organic matter	86.8	90.3	—	91.3	93.0
Ash	13.2	9.7	—	8.7	7.0
Crude protein	12.1	9.9	6.7	4.8	8.7
Ether extract	3.4	2.8	—	1.5	2.4
Crude fiber	32.1	31.4	—	31.0	28.7
N-free extract	39.2	46.2	—	54.0	53.2
Calcium, % dry matter basis	0.50	0.19	0.65	0.44	0.61
Phosphorus, % dry matter basis	0.34	0.23	0.11	0.29	0.27
Carotene, mg/lb wet forage	36.2	47.7	25.3	8.9	28.9

Dry matter content of the forage samples was adequate for grazing forages in all trials. Crude protein was slightly deficient in trials 2 and 5, and deficient in trials 3 and 4, according to the nutrient requirements listed by the National Research Council (N.R.C.) (*18*). The crude protein levels recommended by the N.R.C. (*18*) are 10.5% for normal growth (approx. 1.5 lb. per head daily) of yearling steers and heifers of comparable weight as those used in these trials. The protein supplied by the supplemental feed in trial 3 probably alleviated any possible deficiency.

The carotene content (table 4) of the forages was high in all forage samples with the exception of trial 4, which was considerably lower than the other samples, but not totally deficient. These levels of carotene should supply adequate vitamin A activity to meet the requirements (33 mg. per

head daily) recommended by N.R.C. (*18*) with normal forage intake. This may partially explain the lack of response to the supplemental vitamin A. The results of trial 4 (table 2) could also indicate other nutrient deficiencies, particularly protein, or that sufficient liver vitamin A reserves averted a response to the supplemental vitamin A.

The average daily gain for all animals receiving vitamin A in the five trials was 0.98 lb. compared to 1.01 lb. for all control animals. These results indicate that under the conditions of this study, supplemental vitamin A did not improve the performance of yearling steers and heifers on pasture. Klosterman *et al.* (*17*) found that beef cattle could efficiently utilize carotene from corn silage to meet the vitamin A requirements. The results of the study reported herein are also in agreement with those of other investigators (*7, 8, 20, 32*) who found that supplemental vitamin A did not significantly improve gains when steers were on summer pasture or fed silages.

SUMMARY

Five trials involving a total of 311 yearling steers and 23 heifers were conducted to study the effects of oral and injectable vitamin A upon weight gains of beef cattle on pasture. Under the conditions of this study, neither vitamin A source improved average daily gain when compared to the gains of the control groups in all trials. When all data in the five trials were combined, average daily gains were 0.98 lb. and 1.01 lb. for the vitamin A-supplemented and control animals, respectively. There were no significant differences in daily gains between the two types or between the various levels of supplemental vitamin A.

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